EVIDENCE FOR YOUNG LUNAR VOLCANISM IN MARE VAPORUM REGION FROM MULTI-WAVELENGTH REMOTE SENSING OBSERVATIONS. R.P.Rajasekhar[1,*], Satadru Bhattacharya[1,2], Sumit Pathak[2], Sugali Sekhar Naik[1], Sriram Saran Bhiravarasu[1], Aditya Kumar Dagar[1], A.S.Arya[1]. [1]Space Applications Centre, ISRO, Ahmedabad-380015, India; [2]Dept. of Geology & Geophysics, Indian Institute of Technology, Kharagpur-721302, India; (*rajasekhar@sac.isro.gov.in).

Introduction: Terrain Mapping Camera-2 (TMC-2) onboard Chandryaan-2 mission has similar capabilities as its predecessor TMC-1 onboard Chandrayaan-1 mission. The state-of-the-art, high resolution TMC-2 has along-track 3-view stereo capability [1]. TMC-2 provides panchromatic images with a spatial resolution of 5 m and swath of images is of 20 km [1]. Digital Elevation Model [DEMs] of 10 m spatial resolution are generated from these images obtained by Fore, Aft and Nadir cameras looking at same location on Lunar surface at an angles of +25, 0, -25 degrees respectively.

Morphometric and rheological study of lunar domes is helpful in understanding the volcanic processes. Lunar volcanic domes are broad, convex, and circular to oval landforms of modest positive relief [2]. TMC-2 DEMs are very much useful for estimation of morphometric parameters of lunar domes such as diameter, height, flank slope and volume etc. and rheological properties i.e. viscosity and effusion rate.

In this study, synergistic study of two domes (Fig.1, Table.1) located in northern part of Mare Vaporum region was carried out using CH-2 TMC and other complimentary remote sensing data sets from recent missions (Kaguya-TC, LRO-NAC, CH1-M^3, LRO-miniRF), as Chandryaan-2 - DFSAR S Band & IIRS data sets are not available for this region.

Data used: Ortho image and topography data sets of TMC-2 acquired on 12th December,2019 with a spatial resolution of 5 m/pixel are used for estimation of surface age, morphometric parameters , rheological properties of dome-1. Kaguya's TC DEM was used for estimation of morphometric parameters of dome-2. Images of TMC-2, Kaguya –TC and LRO-NAC are used for surface age estimation of these two domes and adjoining regions. Compositional mapping and study of scattering properties of dome-1 and adjoining region was carried out using datasets obtained from Chandrayaan-1 M^3 and S-band Mini-RF onboard LRO mission respectively.

Methods: A topography image of the two domes in the northern part of Mare Vaporum are shown in Fig. 1a. Ortho images of dome-1, 2 prepared using TMC-2 and Kaguya TC data sets are shown in Fig.1 b,c, respectively. Morphometric parameters (diameter, height, flank slope, volume), of these two domes are measured using the DEMs of TMC-2 and TC datasets (Table 1). Rheological properties (viscosity and effusion rate, Table 2) are estimated for magma density of 2800 kg/m^3. Surface ages of domes, crater floor adjoining dome-1, and adjoining Mare unit are estimated using Crater Size Frequency Distribution (CSFD) method to understand the evolution sequence of different events.

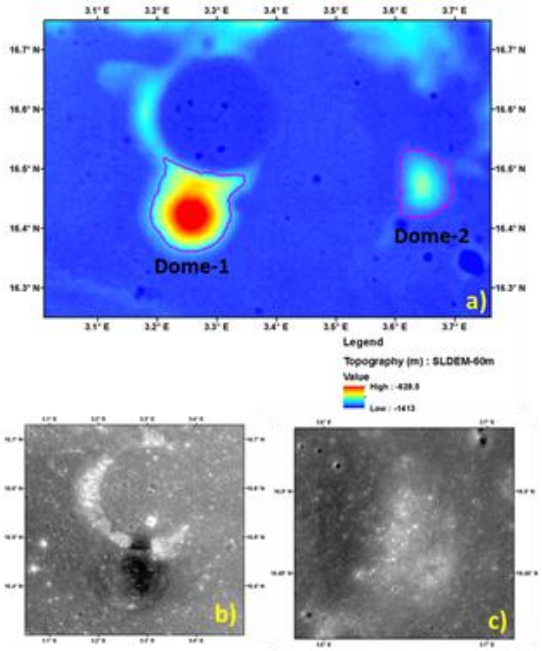

Fig. 1 a) Topography map of two domes and adjoining region, located at northern Mare Vaporum. Locations of dome are indicated by red colored polygons. Orthoimages of dome-1 and dome-2 , captured by CH-2 TMC (b) and Kaguya –TC (c) respectively. This region is located near to northern boundary of Mare Vaporum

Table.1 Morphometric parameters of domes

Dome	Center longitude	Center latitude	Diameter (km)	height (m)	flank slope (deg)	Circularity Index	volume (km^3)
Dome-1	3.26	16.44	4.54	505	12.75	1.13	2.68
Dome-2	3.65	16.47	3.08	190	7.06	1.35	0.47

Table.2 Rheological properties of domes

Dome	Yield strength (Pa)	Viscosity (Pa.s)	E (m^3/s)
Dome-1	1.66E+05	2.02E+09	7.09
Dome-2	3.45E+04	4.67E+07	8.70

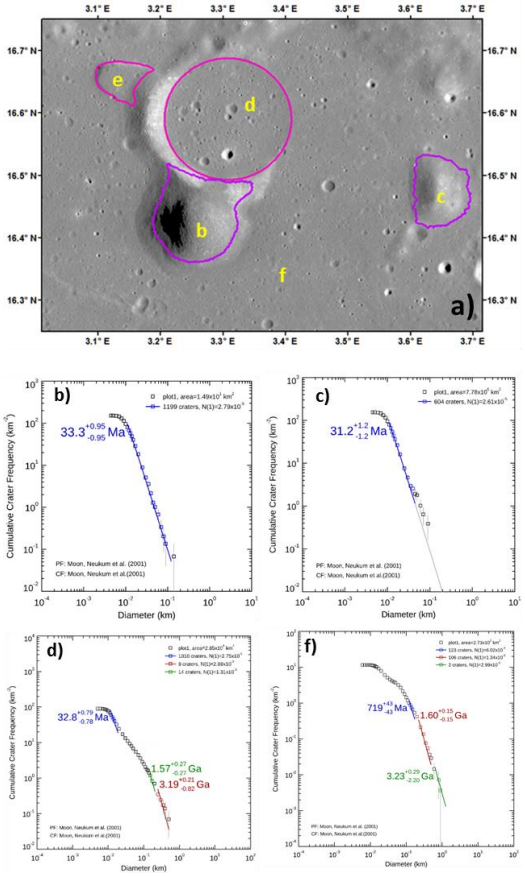

Fig. 2. (a) TC image mosaic of two domes and adjoining region . Crater Size Frequency Distribution (CSFD) plots of dome-1(b), dome-2(c), crater floor adjoining dome-1(d) and, adjoining Mare unit (f) regions are shown.

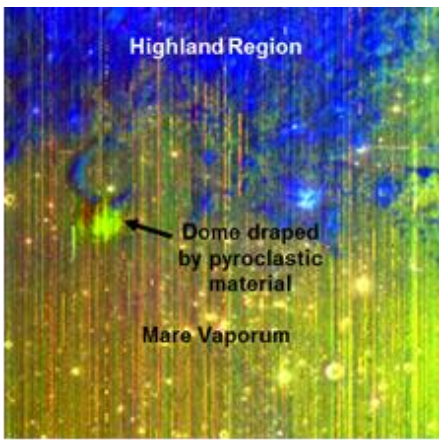

Fig.3 An M^3 Integrated Band Depth (IBD) FCC mosaic (R: 1 micron IBD, G: 2 micron IBD, B: 1.578 micron albedo channel) of the study region

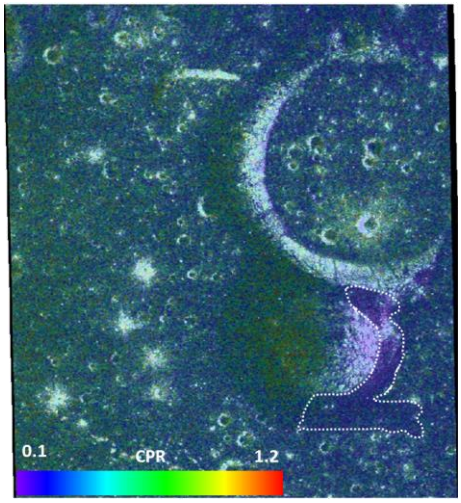

Fig.4 S-band Mini-RF CPR image of dome-1 region stretched to a color scale and overlaid on the total backscatter power image . The dotted white regions shows the extent of pyroclastic deposit in this region.

Results and discussion: Surface ages of dome-1 (b), dome-2(c), crater floor adjoining dome-1 (d) and adjoining Mare unit (f) (as shown in Fig. 2) are estimated using CSFD method are 33.3 Ma (b); 31.2 Ma (c); 1.57Ga, 3.19 Ga (d); 1.69 Ga, and 3.23Ga (f) respectively. Surface ages of two domes indicates that these domes are very young in age (~30 Ma) formed during Copernican period. This indicates that recent volcanic processes might have occurred in this region of the Moon, similar to what has been proposed for some of the Irregular Mare Patches (IMP)s [4]. Crater floor and adjoining mare region might be formed in Eratosthenian to late Imbrian period. Analysis of M^3 data shows that composition of floor of the crater and adjoining Mare unit are similar (Fig.3). Pyroclastic composition is observed over Dome-1. Extent of pyroclastic mantling material as identified from the M^3 image in the eastern part of Dome-1 (Fig. 3) is also indicated by very low S-band CPR values from LRO Mini-RF data (Fig.4). These results indicate association of pyroclastic deposits with young lunar dome-1.

References: [1] Chowdhury, A.R., et al., 2020. Current Science, 118, 4, 566-572. [2] Lena, R., et al. 2013. Springer Verlag. [3] Lena R. and *Barry Fitz-Gerald* et al. (2014), Planet. Space. Sci. 92, 1-15. [4] Braden et al. 2014. Nature Geoscience.7,787-791